

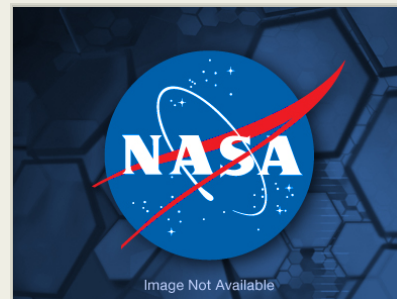
# Atomic drag-free accelerometer for non-gravitational forces in radiometric orbit determination and planetary science measurements

Active Technology Project (2021 - 2023)



## Project Introduction

We propose to further advance the technology maturity of the miniature atomic drag-free accelerometer that was first developed under the Planetary Instrument Definition and Development Program (PIDDP). The accelerometer uses free-fall atomic particles as proof masses and quantum wave interference for inertial force measurements. This novel type of accelerometer will provide unprecedented performance in both sensitivity and stability on-board an orbiter without the need for calibration. The accelerometer measures all of the non-gravitational forces of the spacecraft and thus enables the reduction and elimination of the errors induced into the planetary gravity measurements through radiometric orbit determination. Radiometric gravity measurements have provided unique and valuable information about the interior structure and dynamics of planetary bodies. The confirmation and determination of the fluid core size of Mars are great examples of the science achievable from gravity measurements. For other planetary bodies, where non-gravitational forces are severe and dynamic, an on-board accelerometer will provide the drag-force measurements necessary for obtaining high precision gravity data. The need and benefit of such accelerometers are exemplified by the inclusion of the Italian Spring Accelerometer on Mercury Planetary Orbiter in the BepiColombo mission. The atomic accelerometer instrument technology is based on the quantum atom-wave interferometers. It utilizes quantum interference of neutral atoms, laser cooled to microKelvin temperatures without bulky cryogenics. One major difference of the atomic accelerometer from traditional mechanical accelerometers is the use of totally free-fall proof masses without any spring or measurement back action. This allows for drag-free measurements, and therefore, high acceleration sensitivity and stability without the need of on-board calibrations. Through the PIDDP program we have demonstrated the concept of a miniature drag-free reference instrument, developed from a previous full rack-sized instrument to a simple and shoebox-sized sensor system. The objective of the MatISSE effort is to develop an integrated instrument system to TRL5, perform full characterization and evaluation on the ground, and make it ready for microgravity performance demonstration and validation. With the successful development and validation of the atomic accelerometer technology, future missions to orbit Titan, Enceladus, and Venus will be able to carry the precision U.S. accelerometer. This will enhance gravity measurements by enabling the orbiter to fly low in altitude, for higher gravity signals, without the concern of atmosphere drag-induced errors. With better measurements of gravity higher harmonics and tidal variations, scientists will be able to learn more about the density distribution in depth, shape, and the interior structure of a planet body in hydrostatic equilibrium. For planets with heavy atmospheres such as Venus, one may be able to determine the seasonal atmospheric loading through time-varying gravity measurements.



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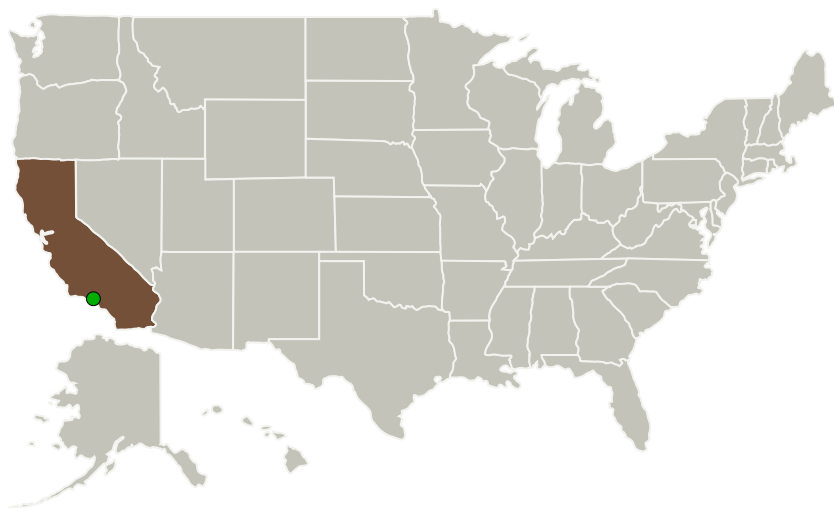
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## Anticipated Benefits

Developing Instrument technology to improve measurements for future planetary science missions.

## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Lead Organization	Academia	Pasadena, California
● Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

## Primary U.S. Work Locations

California

## Organizational Responsibility

### Responsible Mission Directorate:

Science Mission Directorate (SMD)

### Lead Organization:

California Institute of Technology (CalTech)

### Responsible Program:

Maturation of Instruments for Solar System Exploration

## Project Management

### Program Director:

Carolyn R Mercer

### Program Manager:

Haris Riris

### Principal Investigator:

Nan Yu

### Co-Investigators:

Karen R Piggee  
Sang H Park  
James M Kohel  
Bruce G Bills  
Thanh M Le  
Kamjou Mansour  
Sheng-vey Chiow

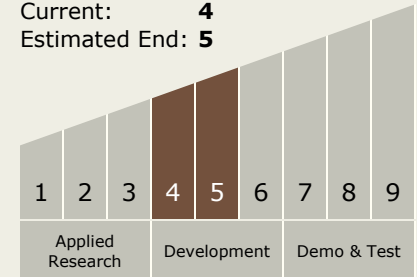
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## Technology Maturity (TRL)

Start: **4**  
Current: **4**  
Estimated End: **5**



## Technology Areas

### Primary:

- TX08 Sensors and Instruments
  - └ TX08.1 Remote Sensing Instruments/Sensors

### Other/Cross-cutting:

- TX08 Sensors and Instruments
  - └ TX08.3 In-Situ Instruments and Sensors
- TX17 Guidance, Navigation, and Control (GN&C)
  - └ TX17.X Other Guidance, Navigation, and Control

## Target Destination

Others Inside the Solar System